ABSTRACT

The Hidden Markov Models (HMMs), powerful statistical models used for modeling sequential data. In this research HMM with Gamma, Gumbel, Normal, Log-Normal and Exponential probability distributions have been used to detect the pattern of annual rainfall in different regions of Pakistan. Based on HMM, a 90-year record of annual total rainfall in different regions of Pakistan from 1931 to 2021 is classified in to five states: arid, semi-arid, humid, semi-humid and wet states. The model is developed to provide necessary information for the farmers, agronomists, water resource management scientists and policy makers to enable them plan for the uncertainty of annual rainfall. The parameters of the multiple HMMs were estimated from the annual rainfall data of Lahore, Sialkot, Khanpur, Faisalabad and Bahawalpur. After which model parameters were estimated using observed rainfall data from key stations are subsequently optimized using optimization techniques to achieve maximum likelihood. After fitting all the models with different numbers of states for different regions selects the model with the lowest AIC (Akaike Information Criterion). Furthermore, our research extends it utility through: Viterbi Algorithm unveil the most probable sequence of hidden states, shedding light on the temporal nuances of rainfall pattern, State Prediction predict the evolution of rainfall states over future time steps, Forecast Distribution provides forecasts of rainfall distribution enhancing resource allocation. The results showed that Gumbel and Log-Normal Hidden Markov Models were the best to detect the pattern of rainfall in different stations of Pakistan.